

REMARKS

In view of the foregoing amendments and following remarks responsive to the first Office Action of September 6, 2001, Applicant respectfully requests favorable consideration of this application.

Claims 21-23 are withdrawn from consideration as a result of Applicant's response to the Restriction Requirement in this application. Accordingly, claims 1-20 were pending in this application. Applicant has herein amended claims 1, 9 and 16 and added new claims 24 through 29. Accordingly, claims 1-20 and 24-29 are now pending in this application.

The Rejections

The Patent and Trademark Office (Office) rejected claims 1, 4-6, 9-10 and 12 under 35 U.S.C. §102(e) as anticipated by Gilleo and claims 2-3, 7-8, 11, and 13-15 under 35 U.S.C. §103(a) as unpatentable over Gilleo. The Office also rejected claims 16-20 under 35 U.S.C. §103(a) as unpatentable over Gilleo in view of Itai.

The Present Invention

The present invention relates generally to flip chip bonding of semiconductors. More particularly, the invention introduces a

new type of solder ball for use in flip chip type bonding. The solder ball comprises a substantially non-deformable dielectric core, a solderable metal layer over the core, and a solder layer over the metal layer. The dielectric core has a higher melting temperature than the solderable metal layer. Some of the advantages of this new type of solder ball are potentially superior high frequency performance, reduction in chemical processing steps, and reduction in lead use.

The Prior Art

The Gilleo reference teaches an electrical bonding method for semiconductors that includes the steps of providing a plurality of deformable, electrically conductive elements, each such element including a thin, flexible metallic layer extending over at least a portion of the surface of the conductive element and connecting the conductive elements to contacts between a microelectronic element and a substrate. The conductive elements comprise shells in the form of a hollow spheroid of a flexible, compressible polymeric material such as an elastomer. It is crucial to Gilleo's invention that the shells be deformable since the purpose of his invention is to provide conductive contact elements that have adaptable height to compensate for deviations from perfect uniformity of the microelectronic element, of the shells themselves, or of the substrate (column 2, lines 41-45).

The Itai reference teaches a ceramic substrate having on the surface thereof a plurality of pads to be attached to terminal

members. Each pad includes a metallic layer formed on the surface of the substrate and a connecting layer made of a nickel based alloy and formed on the metallic layer. The Office has cited Itai only in connection with the rejection of claim 16 and merely for disclosing that a solder region may cover the pads of the devices that are being connected by a solder ball.

Applicant's Response to the Rejections

Applicant has herein amended the independent claims in order to more clearly distinguish over the prior art of record. Particularly, the crux of the Gilleo reference is that the shell that forms the center of the solder ball is deformable, which is achieved, for example, by forming the shells of polymer. However, at least two of the key features of the solder balls of the present invention are that they are substantially non-deformable (see page 5, lines 14-21) and that they have a melt temperature above the melt temperature of the solderable metal layer (see page 5, lines 14-21) in order to maintain that non-deformability during soldering.

As noted in the specification, preferred dielectric materials for the core include ceramic and glass materials.

Applicant has herein amended the independent claims to more clearly recite these distinctions. Particularly, independent claims 1, 9 and 16 now expressly recite that the core is substantially non-deformable. This limitation is supported in the specification at page 5, lines 14-21. This limitation is not

found in Gilleo. In fact, Gilleo clearly teaches away from the present invention in that Gilleo expressly and repeatedly notes that the crux of his invention is that the shells are deformable. Accordingly, Gilleo teaches away from the present invention.

Applicant has further added new independent claims 24 through 26 which are similar to claims 1, 9 and 16, except that they recite that the dielectric core has a melting temperature above the melting temperature of the solderable metal layer, rather than that the cores are substantially non-deformable. This helps assure the non-deformability of the core and also is not taught in Gilleo.

Itai does not contain any relevant teaching with respect to the two distinguishing limitations discussed above.

Since all other original claims depend from one of claims 1, 9 and 16, they distinguish over the prior art of record for the same reasons discussed above. However, claims 2, 3, 10, 11, 17, and 18 even further distinguish over the prior art of record because they expressly recite that the core is formed of a ceramic material or a glass material (depending on the particular dependent claim). Both of those materials are, of course, substantially non-deformable. Gilleo, on the other hand, discloses shells that are formed of deformable polymeric material.

Applicants also have added new dependent claims 27, 28 and 29, which depend from claims 1, 9 and 16, respectively, and add the feature that the solderable metal layer of the solder balls

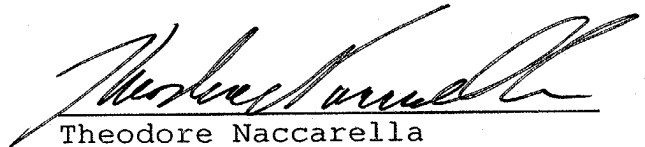
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is 0.1 to 1 micron thick. Accordingly, these claims also further distinguish over the prior art of record since neither Gilleo nor Itai teach these thicknesses.

In view of the foregoing amendments and remarks, this application is now in condition for allowance. Applicant respectfully requests the Examiner to issue a Notice of Allowance at the earliest possible date. The Examiner is invited to contact Applicant's undersigned counsel by telephone call in order to further the prosecution of this case in any way.

Respectfully submitted,



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Marked up Version of Specification

Please replace the paragraph on page 2, line 21, with the following;

Conventional processes for forming solder bumps, however, typically involve photolithography, electroplating and wet chemical etching steps. [Process] Processes of the this type are not entirely satisfactory for a number of reasons, including (1) the requirement of chemical processing steps, (2) the use of numerous processing steps, and (3) high lead usage, which can lead to higher costs and adverse environmental impact.

Please replace the paragraph starting on page 8, line 4, with the following;

A specific example in which numerous solder-coated articles are attached to a semiconductor substrate follows. First, 68+/-5 micron copper coated glass spheres (e.g., product number GL-263 from Mo-Sci Corp.) Are obtained and coated by barrel electroplating with a solder layer comprising 63% Sn and 37% Pb to provide solder-coated articles. A wafer with solder pads (in this example, a silicon wafer comprising Ti(550°Å)/Pt(1000 Å)/Au(2000 Å) solder pads as well as nitride and benzocyclobutene (BCB) passivation/moisture layers) is preheated to a temperature of about 100°C. The solder-coated articles are

then placed into an open container forming a monolayer of spheres in the container. Adjacent to this container is another shallow container containing a specified volume of flux. A dual head assembly is then provided, which contains (1) a pick-up tool and (2) a bed of small round cylinders. The pick-up tool consists of a Teflon/stainless steel sheet machined with .002-inch (i.e., approximately 50 micron) diameter through-holes. The location and number of the holes will match location on the wafer where the solder spheres are to be attached (i.e., the solderable pads). The bed of cylinders is arrayed in the same fashion so as to contact the solderable pads on the wafer. Equipment of this type is well known in the art of BGA (ball grid arrays) for placement of solder balls on printed circuit boards.

Please replace the paragraph starting on page 8, line 21, with the following;

The dual head assembly operates such that (1) the bed of cylinders is lowered into the container of flux, contacting the surface of the flux and (2) at the same time, a vacuum is applied to the [pickup] pick-up tool as it is dipped into the container of spheres, causing each hole of the pick-up tool to be filled with a single solder-coated article. Using a pattern recognition system, the head with the flux-coated bed of cylinders is aligned over the wafer. Upon a slight vertical motion, the tip of each cylinder contacts each solderable pad on the wafer, leaving a certain volume of flux on the pad. Once complete, this head is

raised and the pick-up head with the spheres is [than] then located directly over the flux coated solder pads on the wafer. The pick-up head is then lowered gently until the base of each solder coated sphere contacts the flux. The vacuum in the [pick up pick-up] head is then shut off and the [pick up] pick-up head is raised, leaving the spheres on the flux coated solder pads on the wafer. The wafer is shuttled through a tunnel oven set with the appropriate reflow temperature profile.

Marked Up Version of the Claims

Please replace claim 1 with the following claim 1.

1. A solder-coated article comprising:

a substantially non-deformable dielectric core having a largest dimension ranging from 1 to 1000 microns;
a solderable metal layer over said core; and
a solder layer over said metal layer.

Please replace claim 9 with the following claim 9.

A modified substrate comprising:

a substrate;

a metalized pad on said substrate; and

A bump feature on said metalized pad, said bump feature comprising a substantially non-deformable dielectric core; a solderable metal layer over said core; and a solder region contacting at least a portion of said solderable metal layer and at least a portion of said metalized pad.

Please replace claim 16 with the following claim 16.

A solder bonded assembly comprising:

a first substrate comprising a first solder pad;

a second substrate comprising a second solder pad;

a substantially non-deformable dielectric core provided with a solderable metal layer and disposed between said first and second solder pads; and

a solder region covering at least a portion of each of (a) said first solder pad, (b) said second solder pad and (c) said solderable metal layer.